International Journal of Botany
and Research (IJBR)
ISSN(P): 2277-4815; ISSN(E): 2319-4456
Vol. 7, Issue 4, Aug 2017, 23-36

APPLICATION OF FLY ASH INCREASES THE YIELD OF PEA (*PISUMSATIVUM L.*)

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ABSTRACT

The present study has been undertaken for proper management of fly ash in agricultural soils. Experiments were conducted in agriculture soil, amended with organic matter, and inoculated with phosphate solubilizers, nitrogen fixers and AM fungi. Efforts were made to develop a package for improving the yield of Pea (Pisumsativum) in fly ash amended agricultural soil.

KEYWORDS: AM Fungi, Fly ash, Nitrogen fixer, Pea, Phosphate Solubilizers & Yield

Received: Jun 18, 2017; **Accepted**: Jul 12, 2017; **Published**: Jul 18, 2017; **Paper Id**.: IJBRAUG20174

Original Article

INTRODUCTION

The current annual production of major coal combustion residues (CCRs) is estimated to be 600 million worldwide, of which about 500 million ton (70-80%) is FA (Ahmaruzzaman 2010). More than 112 million ton of FA is generated annually in India alone, and projections show that the production (including both FA and bottom ash) may exceed 170 million ton per annum by 2015 (Pandey *et al.* 2009, Pandey and Singh 2010). Disposal and utilization of such large quantities of fly ash is an universal problem.

Coal available for use in TPSs in the country carries 30 to 50 percent of ash. Disposal of ash from such TPSs is a challenging issue particularly in situations when available land area for disposal are limited and lies in the vicinity of urban and potential agricultural belts. Further the inherent nature of ash brings adverse effects to the environment and ecological features of the region.

Fly Ash Use in Agriculture

Fly ash (FA) consists of practically all the elements of soil except organic carbon and nitrogen and can be utilized as a resource material (Sharma *et al.*). A survey of literature clearly reveals that there has been considerable interest and efforts regarding use of FA as resource material in agriculture and related fields. Application of fly ash into agricultural soils as an amendment or as fertilizer has been reported to change the soil texture from clayed to loamy and from sandy clay to loamy clay and structure in a way to improve the availability of soil water, air and nutrients by increasing porosity, water holding capacity, electrical conductivity and hydraulic conductivity and decreasing bulk density and surface encrustation. Soil pH also affected by fly ash use and thus, it may be used to reclaim both alkaline as well as acidic soils. Bio modification further increases the efficiency. Fly ash has been tried alone or in combination with materials like farm yard manure, sewage sludge, water hyacinth, microbial cultures, gypsum and lime and has been found to improve the growth, yield and nutrients uptake of various agricultural crops, plantations and vegetables.

AM Fungi

The main limiting factor of fly ash for its use in agriculture is that, it is deficient in nitrogen and phosphorus, low soil microbial activity, and has high pH. Because of this, the sole application of fly ash has been reported to reduce the establishment and germination of transplant plants. This is thought to be primarily due to a lack of N, which is volatilized during combustion. In order to nullify the adverse effects of fly ash and to improve the N and P status of crops and soils there is need to explore the use of bio-inoculants, especially the nitrogen fixers, phosphate solubilisers and P-scavengers, the VA mycorrhizae. Mycorrhizal association is known to reduce the uptake of heavy metals in shoots of the plant growing in soils with high concentration of readily available metals (Schepp*et al*., 1987). The translocation of potentially toxic heavy metals to the shoots seemed to be reduced in mycorrhizal plants possible by retention of the metals in the hyphae of fungus within the root cells.

Nitrogen Fixing Micro-Organisms

Nitrogen fixing plant species have been emphasized amongst the pioneer communities for the stressed land development of abandoned fly ash and bottom ash basins. Most of these are deficient in organic matter and nitrogen, causing a danger for the survival of the transplanted tree seedlings. The nitrogen fixing microbes play an important and decisive role in the restoration of such lands. Fixation by free-living bacteria is often negligible because of lack of suitable carbon substrates. However, nodulated plants can be of great use in building up soil fertility.

Phosphate Solubilizing Microbes

Fly ash is generally poor in phosphorus, especially the available phosphorus, limiting the growth of seedlings. There are a number of soil microbes *viz., Pseudomonas striata, Bacillus polymyxa, B. megaterium, B. pulvifaciens, B. circulans, Citrobacter sp., Aspergillusawamori, Penicilliumdigitatum, Aspergillusniger*etc. Which solubilize insoluble Al and Ca phosphates and rock phosphate and increase the availability of phosphates to the plants?

MATERIALS AND METHODS

Site Description

For conducting the experiments in the present study, both fly ash and agriculture soil were used. Fly ash was collected from the fly ash dumping sites situated at IFFCO, Phulpur, 25°33’N, 82°6’E near Allahabad, Uttar Pradesh and the agriculture soil from Ganga basin region of Allahabad. Characteristics of agriculture soil and FA used in the experiments are presented in Table-1.

Collection of Soil Samples

The rhizospheric soil samples were collected from the root region of the plants growing in the vicinity of fly ash damping site of IFFCO, Phulpur, and Allahabad. Samples were brought to the laboratory in polythene bags and stored at 5°c until processed.

Isolation of AM Fungi

AMF spores were isolated by wet sieving and decanting method of Gerdemann and Nicolson (1963). A known amount of soil was dissolved in water. After thorough shaking, it was left for some time for the soil particles to settle down. The clear solution was passed through sieve of 500, 350, 210, 150, 90 and 60 micro meters in descending order. The AM spores retained on various sieves were transferred on filter papers. Filter papers were examined under binocular microscope.

Identification of AM Fungi

Different VAM spores present in the soil were recovered and AM spores were mounted in PVLG and identified to the species level using the synoptic keys of Trappe (1982), Schenck and Parez (1990) and INVAM species guide (http//: invam.caf.wvu.edu).The most dominant indigenous AM fungi were the species of *Acaulospora* and *Glomusviz. Acaulospora denticulate*, *Acaulosporascrobiculata*, *Glomusdeserticola*, *Glomusfasiculatum*, *Glomustortosum*, *Glomusclarum*, *Glomusmulticaule*, *Glomusintraradices*, *Glomusmosseae*, *Glomusmulticaule*, *Gigaspora* sp. etc.

Maintenance of Trap Culture

To obtain abundant and healthy spores of different AMF species rhizospheric soils from the plants growing in the vicinity of fly ash dumping site were collected. Shoots were removed at crown and roots were chopped into small fragments. These root segments along with rhizospheric soil were mixed with autoclaved coarse sand soil mixture 1:1 ratio (v/v). These mixtures were then transferred to sterilized earthen pots and seeds of *Trifoliumrepens* were sown in each pot. Cultures were grown under greenhouse conditions for three months. After three months, spore population was determined in trap cultures. Another set of trap cultures was prepared on *Sorghum bicolor* using the soil of first set. Mycorrhizal inoculum consisted of soil having 50 AM spores/10 gm. soil, mycelia and infected root fragments (95% root length colonization). This consortium was used as inoculum for the experimental work.

Isolation and Maintenance of Phosphate Solubilizing Microbes

Soil dilution and plate count method of Timonin (1940) was used for isolating/counting of phosphate solubilizing microbes from the rhizospheric soil of the plants growing in the vicinity of fly ash dumping site IFFCO, Phulpur, Allahabad. The composite samples were used, as counts obtained from individual samples did not substantially vary from those obtained from the composite sample in the preliminary experiments conducted for standardizing the method.

Root of plants growing in the vicinity of fly ash dumping site (IFFCO) with adhering soil were washed thoroughly in flask containing 100 ml sterilized distil water. It was shaken thoroughly for ten minutes. 10ml of the suspension containing composite sample of rhizosphere soil was transferred to a flask containing 90ml sterilized distilled water. The diluted suspension was further diluted a number of times in the same way so as to get the desired dilution. The final dilution used for plating was selected on the basis of counts obtained in the preliminary experiments and varied from 1/10000 to 1/10, 00000. In general, the dilution which gave counts between 20-30 colonies of fungi/plate was selected.

For the isolation of phosphate solubilizing microbes, 0.5ml of aliquot of appropriate dilutions were plated in sterilized Petri plates containing 10ml of Pikovskaya's Medium (Glucose, 10g; Tricalcium Phosphate, 5.0g; Ammonium Sulphate, 0.5g; Sodium Chloride, 0.2g; Magnesium Sulphate, 0.1g; Yeast Extract, 0.5g; Ferrous Sulphate, traces; Manganese Sulphate, traces; Agar, 15g; Distilled water, 1000ml). The petriplates were rotated by hand in broad swirling motions to distribute the suspension over the medium. Five replicates were taken for each sample. After incubation at 28 ± 2^{0}C, usually for 24-48 hours, the resulting colonies were identified and counted. The Petri plates containing fungal spreads or large clear zones of antagonisms were discarded. All the colonies of phosphorus solubilizing microbes which appeared on the Petri plates and exhibited zone of solubilization were examined carefully and sub-cultured in Pikovskaya's broth media. They were re-examined critically, identified with the help of specific monographs and maintained for detailed study on their phosphate solubilizing potential.

Isolation and Maintenance of N_2- Fixing Bacteria, Rhizobium Leguminosarum

The plants of pea growing in the fields near the fly ash dumping site, IFFCO, Phulpur, Allahabad were carefully uprooted washed thoroughly and healthy and pink nodules were detached from the roots. Nodules were surface sterilized with 3-5% sodium hypochlorite for 5 min and repeatedly rinsed with sterile distilled water 3-4 times to remove the excess sterilizing agent. The sterilized nodules were then crushed in double distilled water and a uniform suspension of *Rhizobia* with water was formed. Serial dilution (1:10 to 1:1000) of nodules extracts were plated on Yeast extract Mannitol Agar plates [Di- potassium hydrogen Phosphate, 0.5g; Magnesium sulphate, 0.2g; Sodium Chloride, 0.1 g; Mannitol, 10g; Yeast Extract, 1.0 g; 1% Congo red solution, 2-5 ml; Agar, 20g; Distilled water, 1000 ml (Vincent, 1970)]. The plates were incubated for 10 days at 26±2°c. Large gummy colonies of bacteria that emerged within four or five days were selected, isolated and subsequently transferred on fresh nutrient plates and sub cultured.

Experimental Setup

The experimental plant materials *Pisumsativum var. AP3,* were procured from registered seed shop of Allahabad, which served as the unit of propagation during the experiments.

Experimental Design

An experiment was setup in pots under greenhouse condition to assess the performance of both the crops raised in agriculture soil of Allahabad amended with organic matter (*Cynodon* 2% w/w), different concentration of fly ash (10, 20, 30%) and inoculated with consortium of AM fungi, PSF and *Rhizobium* alone as well as in combination.

The experiment had a complete randomized design in three blocks, eight treatment/block and three replicates/treatment. The treatment were as follows

Block I

- Agriculture soil (Control)
- Agriculture soil + Phosphate solubilizing fungi (*Aspergillusniger*) (PSF)
- Agriculture soil + AM
- Agriculture soil+ *Rhizobium* (RHZ)
- Agriculture soil + AM+PSF
- Agriculture soil+PSF+RHZ
- Agriculture soil+AM+RHZ
- Agriculture soil+PSF+AM+RHZ

Block II

- Agriculture soil + Organic matter (*Cynodon* 2% w/w) (CN)
- Agriculture soil + CN + Phosphate solubilizing fungi (*Aspergillusniger*) (PSF)
- Agriculture soil + CN+AM

- Agriculture soil + CN + RHZ
- Agriculture soil + CN+AM +PSF
- Agriculture soil + CN+PSF+RHZ
- Agriculture soil + CN+AM+RHZ
- Agriculture soil + CN+AM +PSF+RHZ

Block III

- Agriculture soil +10% Fly ash
- Agriculture soil + Organic matter (CN) + 10% Fly ash + PSF
- Agriculture soil + CN + 10% Fly ash + AM
- Agriculture soil + CN + 10% Fly ash +RHZ
- Agriculture soil + CN + 10% Fly ash +AM + PSF
- Agriculture soil + CN+ 10% Fly ash +PSF + RHZ
- Agriculture soil + CN + 10% Fly ash + AM + RHZ
- Agriculture soil + CN + 10% Fly ash +AM + PSF + RHZ

Block IV

- Agriculture soil +20% Fly ash
- Agriculture soil + CN+ 20% Fly ash +PSF
- Agriculture soil + CN + 20% Fly ash+ AM
- Agriculture soil +CN + 20% Fly ash + RHZ
- Agriculture soil + CN + 20% Fly ash +AM + PSF
- Agriculture soil + CN + 20% Fly ash + PSF + RHZ
- Agriculture soil +CN + 20% Fly ash + AM + RHZ
- Agriculture soil +CN + 20% Fly ash +AM + PSF + RHZ

Block V

- Agriculture soil +30% Fly ash
- Agriculture soil + CN + 30% Fly ash + PSF
- Agriculture soil + CN + 30% Fly ash + AM
- Agriculture soil +CN + 30% Fly ash + RHZ
- Agriculture soil +CN + AM + 30% Fly ash + PSF

- Agriculture soil +CN + 30% Fly ash+ PSF + RHZ
- Agriculture soil + CN + 30% Fly ash + AM + RHZ
- Agriculture soil +CN + 30Fly ash + AM+ PSF + RHZ

Earthen pots were filled with 4 kg soil amended with 2% (w/w) organic matter. All series supplemented with organic matter except control series. Some sets of experiments were provided with microbial inoculation singly as well as in dual and triple combination.

The above mentioned series were set up in five blocks. In first block all control series were included. In the second block, soil was amended with *Cynodon.* In the third block, soil was amended with 10% fly ash, whereas in fourth and fifth blocks with 20 and 30% fly ash respectively. Pots containing soil without any amendments were maintained as control for the experiment.

Crop was raised in earthen pots. Seeds were surface sterilised by 3 % (v/v) sodium hypochloride solution for 2-3 minutes and rinsedin sterilized distilled water 2-3 times and dried in shade for 10-15 minutes. In single inoculation series with AM, before sowing the seeds, the mycorrhizal inoculum of AM fungi was separately placed below the seeds by the layering method (Menge*et al*., 1977). The inoculum was spread as a layer at a depth of 3-5 cm in the pot and the seeds were sown just above the inoculum layer. The seeds were covered with a layer of soil to ensure an efficient host fungus association. The inoculum consisted of a mixture of infected root pieces and soil with extrametrical spores from cultures of different AM fungi maintained on *Sorghum vulgare* (L.). In single inoculation series with *Rhizobium*, before sowing, the seeds were soaked for 4 hrs in culture suspensions of the isolates of *Rhizobium* (containing approximately 10^8 cells / ml) prepared from its 8 days old cultures on YEMA liquid medium. For single inoculation series with PSF (*Aspergillusniger*) the seeds were soaked for four hrs in culture suspension (containing approximately 10^8 conidia / ml) prepared from the 10 days old culture on Pikovskayas liquid medium. For dual inoculation series involving *Rhizobium* and PSF, the crops were raised from seeds treated with a mixture of an equal amount of culture suspensions containing 10^8 cells or conidia/ml. On the other hand, in dual inoculation series involving *Rhizobium* or PSF and AM fungi, the crops were raised from *Rhizobium*/PSF treated seeds in soil supplemented with inoculum of AM fungi. In triple inoculation series involving *Rhizobium*, PSF and AM fungi, the crops were raised from the seeds treated with *Rhizobium* and PSF supplemented with inoculum of AM fungi. The seeds treated with *Rhizobium* or PSF in single, dual or triple inoculated series were then dried in shade and shown at 10 seeds per pot.Ten seeds per pot were sown and after finally emergence and establishment only five seedlings per pot were maintained. Five plants from each treatment series were carefully uprooted at fruiting stages of plant growth. Data on number of pods, fresh and dry weight of pods and seeds were recorded.

Yield

Number of pods, fresh and dry weight of pods and seeds for each treatment was determined separately at the time of harvest. For recording the dry weight of the pods and seeds the samples were oven dried at 70°C for 48 hrs.

Table 1: Physico-Chemical Characteristics of Agriculture and Fly Ash

	Agriculture Soil Fly Ash	
Physical Properties		
BD (g cm^{-1})	1.5	<1.0
W.H.C (%)	22-25	35-40
EC (m.mhos/cm)	0.82	1.14

Table 1: Contd.,		
Chemical Properties		
pH	8.1	7.4
Aluminium (ds Al_2O_3)	1.0	10 – 20 %
Iron (ds Fe_2O_3)	0.37	3 – 7 %
Calcium(ds CaO)	0.39	1.5 – 2.5 %
Magnesium (ds MgO)	0.24	0.5 – 1.5 %
Sodium (ds Na_2O)	0.008	0.05 – 0.10 %
Potassium (ds K_2O)	232(kg/hac.)	2.0 – 3.0 %
Total Sulphur (ds SO_3)	0.19	0.1- 0.15 %
Organic carbon	0.12%	0.42 %
Nutrient		
Nitrogen	24(kg/hac.)	0.1 – 0.5 %
Phosphorus (ds P_2O_5)	29(kg/hac.)	0.3 – 0.5 %
Heavy Metals		
Cu	_	51.95 (ppm)
Zn	_	145.38 (ppm)
Mn	_	394.30 (ppm)
Fe	_	4.94 (ppm)
Cr	_	55.38 (ppm)
Pb	_	84.70 (ppm)
Cd	_	7.54 (ppm)
Co	_	39.85 (ppm)
As	_	52.78 (ppm)
Ni	_	38.73 (ppm)
Se	_	2.08 (ppm)
Mo	_	8.09 (ppm)

RESULTS

Table 2: Average Number of Pods of Pea Raised in Agricultural Soil Amended With 10 %, 20% and 30% Fly Ash and *Cynodon* and Provided with Consortium of AM Fungi, PSF and N Fixer Alone As Well As in Combination

Average Number of Pods / Plant					
Treatment	**AgS**	**CN**	**10% FA + CN**	**20% FA + CN**	**30% FA + CN**
Control	2	5	4	3	3
+PSF	5	6	8	7	6
+AM	6	7	10	9	7
+RHZ	4	8	18	16	14
+PSF+AM	8	13	12	11	9
+PSF+RHZ	7	11	8	7	6
+AM+RHZ	10	15	15	13	11
+PSF+AM+RHZ	12	18	23	20	18

Table 3: Fresh Weight of Pods of Pea Raised in Agricultural Soil Amended with 10 %, 20% and 30% Fly Ash and Cynodon and Provided With Consortium of AM Fungi, PSF and N Fixer Alone As Well As in Combination

Fresh Weight (G) of Pods / Plant					
Treatment	**AgS**	**CN**	**10% FA + CN**	**20% FA + CN**	**30% FA + CN**
Control	2.676	7.86	10.568	6.099	3.566
+PSF	7.280	9.984	30.968	26.096	20.898
+AM	9.408	12.131	39.530	34.479	24.724

Table 3: Contd.,					
+RHZ	5.688	11.528	64.980	54.976	39.620
+PSF+AM	13.512	22.048	51.312	42.603	33.048
+PSF+RHZ	10.213	16.192	29.184	22.680	18.630
+AM+RHZ	17.550	26.745	71.625	50.895	40.546
+PSF+AM+RHZ	21.384	32.256	113.275	86.640	68.958

Table 4: Dry Weight of Pods of Pea Raised in Agriculture Soil Amended with 10%, 20% and 30% Fly Ash and *Cynodon* and Provided with Consortium of AM Fungi, PSF and N Fixer Alone As Well As in Combination

Dry Weight (g) of Pods / Plants					
Treatment	**AgS**	**CN**	**10% FA + CN**	**20% FA + CN**	**30% FA + CN**
Control	0.628	2.090	2.012	1.017	0.456
+PSF	2.065	2.562	6.656	5.061	3.366
+AM	2.514	3.017	14.130	11.493	8.001
+RHZ	1.328	3.368	13.230	9.680	8.358
+PSF+AM	3.424	5.954	20.532	14.564	10.899
+PSF+RHZ	2.919	4.807	10.168	5.096	3.828
+AM+RHZ	4.390	6.975	26.970	17.589	13.816
+PSF+AM+RHZ	5.424	8.478	41.791	30.62	25.002

Table 5: Fresh Weight of Seeds of Pea Raised in Agriculture Soil Amended with 10%, 20% and 30% Fly Ash and *Cynodon* and Provided with Consortium of AM Fungi, PSF and N Fixer Alone as Well as in Combination

Fresh Weight of Seeds (g) / Plant					
Treatment	**AgS**	**CN**	**10% FA + CN**	**20% FA + CN**	**30% FA + CN**
Control	0.068	0.215	0.184	0.123	0.117
+PSF	0.605	0.888	1.264	1.022	0.852
+AM	1.230	1.477	3.340	2.952	2.219
+RHZ	0.432	1.088	2.484	1.952	1.610
+PSF+AM	1.784	3.159	4.164	3.696	2.889
+PSF+RHZ	0.938	1.529	1.888	1.484	1.230
+AM+RHZ	2.360	3.780	5.430	4.511	3.674
+PSF+AM+RHZ	3.024	4.788	8.717	7.160	6.012

Table 6: Dry Weight of Seeds of Pea Raised in Agriculture Soil Amended with 10%, 20% and 30% Fly Ash and *Cynodon* and Provided with Consortium of AM Fungi, PSF and N Fixer Alone As Well As in Combination

Dry Weight of Seeds (g) / Plant					
Treatment	**AgS**	**CN**	**10% FA + CN**	**20% FA + CN**	**30% FA + CN**
Control	0.006	0.025	0.028	0.012	0.009
PSF	0.030	0.048	0.080	0.049	0.036
+AM	0.072	0.098	0.160	0.099	0.056
+RHZ	0.020	0.056	0.144	0.096	0.056
+PSF+AM	0.120	0.208	0.228	0.165	0.0117
+PSF+RHZ	0.049	0.099	0.096	0.077	0.048
+AM+RHZ	0.160	0.270	0.300	0.208	0.154
+PSF+AM+RHZ	0.228	0.432	0.575	0.460	0.378

DISCUSSIONS

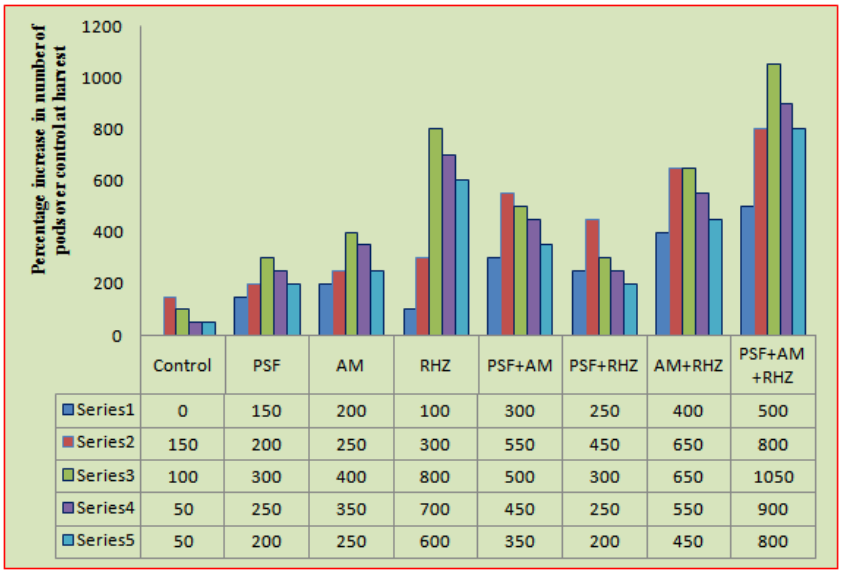
In the present study, triple inoculation series, where the soils were inoculated with AM, PSF and nitrogen fixer, showed improvement in yield in comparison to non-inoculated control, single or dual inoculation. Juwarkar and Jambhulkar (2007) also recorded a 4.5 times increase in the nitrogen content due to addition of *Bradyrhizobium* and *Azotobacter* species, while phosphate content was increased by 10.0 times due to addition of AM, which helps in phosphate immobilization. Due to biofertilizer inoculation, different microbial groups such as *Rhizobium*, *Azotobacter* and AM spores, which were practically absent in fly ash improved to 7.1×10^7, 9.2×10^7 CFU/g and 35 AM spores/10 g of fly ash, respectively. Kumar *et al.* (2001) also reported better growth performance and nutrition in cowpea when inoculated with AM, *Azotobacter* and *Rhizobium.*

Maximum yield in the crop was also recorded in a series where agriculture soil was amended with 10% FA and *Cynodon* and inoculated with all the three microbial inoculants. In comparison to control the same series showed up to1050% increase in pods number in pea, pods fresh weight increased up to 4132.9% in pea while pods dry weight increased up to 6554.6% in pea. Likewise in comparison to control seeds fresh weight increased up to 12719% in pea while seeds dry weight increased up to 9483.3% in pea (Table 2,3,4,5,6), (figure 1,2,3,4,5).

The gradual decline in the measured parameters of pea above 10% fly ash may be due to salinity caused by the higher levels of sulphates, chlorides, carbonate and bicarbonate in the amended soil. Excessive uptake of the elements and their subsequent accumulation in the plants may have accounted for the reduced yield of pea. Similar responses have been reported by Aitken and Bell (1985) and Khan and Khan (1996), (Jala and Goyal, 2006), Pandey and Singh (2010).

Decline in measured parameters above 10% fly ash may also be due to reduction in bioavailability of some nutrients due to high pH, high salinity and high content of phytotoxic elements (Pandey and Singh, 2010; Khan and Khan, 1996, Sharma and Kalra, 2003). Some toxic compounds (Helder*et al*., 1983) and metals *viz.*, nickel, arsenic, cadmium, chromium, lead, selenium, zinc, copper etc. present in the fly ash accumulate in plants beyond the threshold level causes reduction in plant yield (Sharma *et al*., 2010;Siddiqui*et al*., 2004,Gupta and Sinha, 2007;Mishra *et al*., 2007;Yunusa*et al*., 2006).

APPENDICES



	Control	PSF	AM	RHZ	PSF+AM	PSF+RHZ	AM+RHZ	PSF+AM +RHZ
Series1	0	150	200	100	300	250	400	500
Series2	150	200	250	300	550	450	650	800
Series3	100	300	400	800	500	300	650	1050
Series4	50	250	350	700	450	250	550	900
Series5	50	200	250	600	350	200	450	800

Figure 1

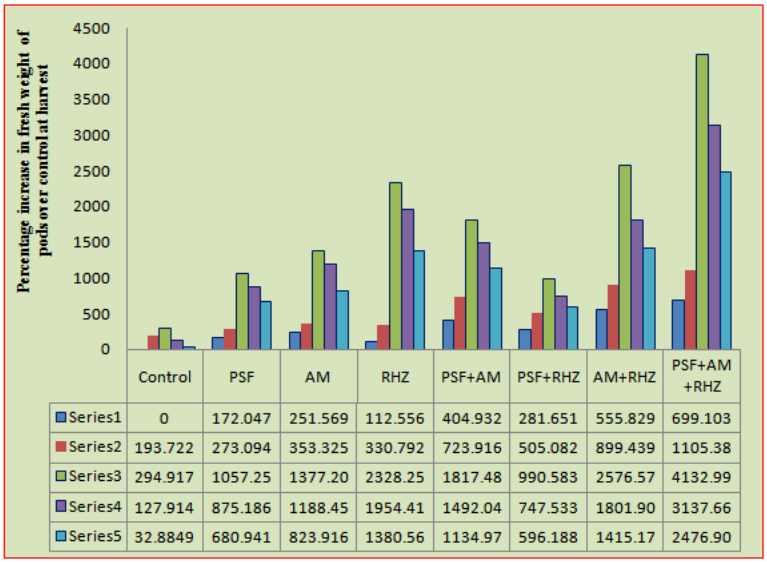
Series1 :AgS (Agriculture soil)

Series2 :AgS+CN (*Cynodon*)

Series3 : AgS+CN+10%FA (Fly ash)

Series4 : AgS+CN+20%FA

Series5 : AgS+CN+30%FA



	Control	PSF	AM	RHZ	PSF+AM	PSF+RHZ	AM+RHZ	PSF+AM +RHZ
Series1	0	172.047	251.569	112.556	404.932	281.651	555.829	699.103
Series2	193.722	273.094	353.325	330.792	723.916	505.082	899.439	1105.38
Series3	294.917	1057.25	1377.20	2328.25	1817.48	990.583	2576.57	4132.99
Series4	127.914	875.186	1188.45	1954.41	1492.04	747.533	1801.90	3137.66
Series5	32.8849	680.941	823.916	1380.56	1134.97	596.188	1415.17	2476.90

Figure 2

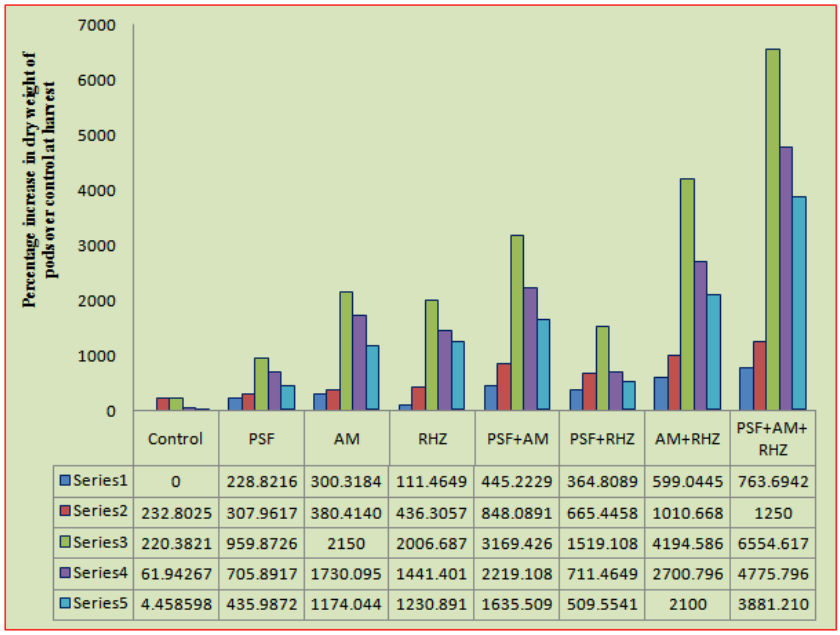
Series1 :AgS (Agriculture soil)

Series2 :AgS+CN (*Cynodon*)

Series3 : AgS+CN+10%FA (Fly ash)

Series4 : AgS+CN+20%FA

Series5 : AgS+CN+30%FA



	Control	PSF	AM	RHZ	PSF+AM	PSF+RHZ	AM+RHZ	PSF+AM+ RHZ
Series1	0	228.8216	300.3184	111.4649	445.2229	364.8089	599.0445	763.6942
Series2	232.8025	307.9617	380.4140	436.3057	848.0891	665.4458	1010.668	1250
Series3	220.3821	959.8726	2150	2006.687	3169.426	1519.108	4194.586	6554.617
Series4	61.94267	705.8917	1730.095	1441.401	2219.108	711.4649	2700.796	4775.796
Series5	4.458598	435.9872	1174.044	1230.891	1635.509	509.5541	2100	3881.210

Figure 3

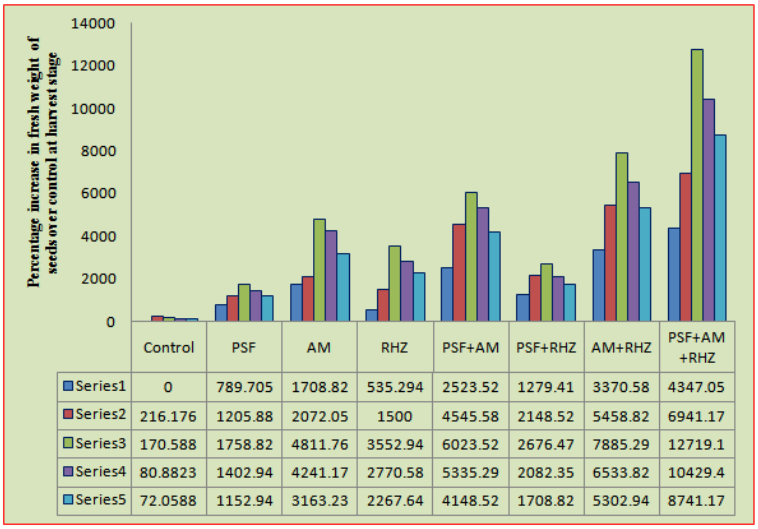
Series1 :AgS (Agriculture soil)

Series2 :AgS+CN (*Cynodon*)

Series3 : AgS+CN+10%FA (Fly ash)

Series4 : AgS+CN+20%FA

Series5 : AgS+CN+30%FA



	Control	PSF	AM	RHZ	PSF+AM	PSF+RHZ	AM+RHZ	PSF+AM +RHZ
Series1	0	789.705	1708.82	535.294	2523.52	1279.41	3370.58	4347.05
Series2	216.176	1205.88	2072.05	1500	4545.58	2148.52	5458.82	6941.17
Series3	170.588	1758.82	4811.76	3552.94	6023.52	2676.47	7885.29	12719.1
Series4	80.8823	1402.94	4241.17	2770.58	5335.29	2082.35	6533.82	10429.4
Series5	72.0588	1152.94	3163.23	2267.64	4148.52	1708.82	5302.94	8741.17

Figure 4

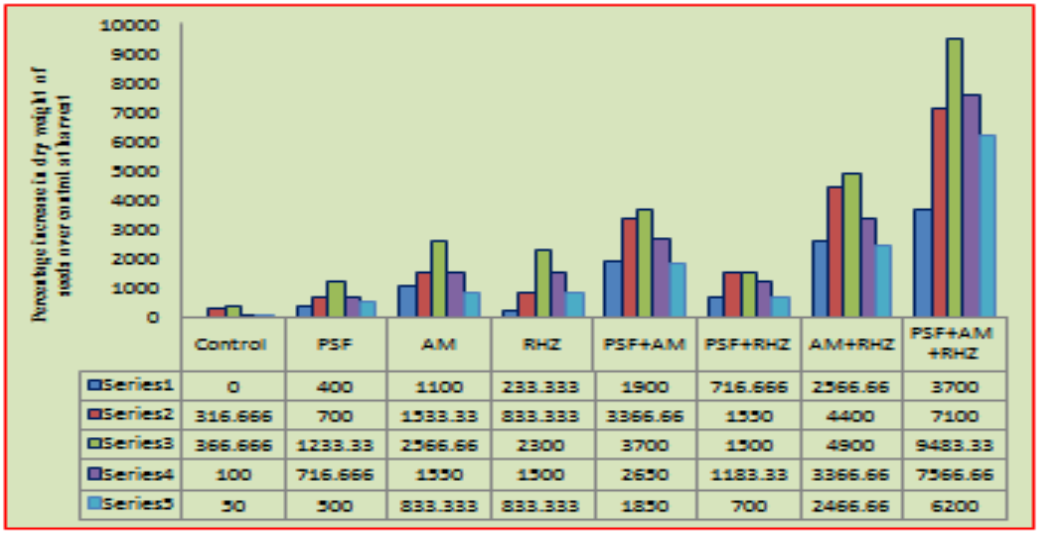
Series1 :AgS (Agriculture soil)

Series2 :AgS+CN (*Cynodon*)

Series3 : AgS+CN+10%FA (Fly ash)

Series4 : AgS+CN+20%FA

Series5 : AgS+CN+30%FA



	Control	PSF	AM	RHZ	PSF+AM	PSF+RHZ	AM+RHZ	PSF+AM +RHZ
Series1	0	400	1100	233.333	1900	716.666	2566.66	3700
Series2	316.666	700	1533.33	833.333	3366.66	1550	4400	7100
Series3	366.666	1233.33	2566.66	2300	3700	1500	4900	9483.33
Series4	100	716.666	1550	1500	2650	1183.33	3366.66	7566.66
Series5	50	500	833.333	833.333	1850	700	2466.66	6200

Figure 5

Series1 :AgS (Agriculture soil)

Series2 :AgS+CN (*Cynodon*)

Series3 : AgS+CN+10%FA (Fly ash)

Series4 : AgS+CN+20%FA

Series5 : AgS+CN+30%FA

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